UC SOUTHERN REGIONAL LIBRARY FACILITY
G 000 005 534 3
WL
20
S456g
1883





GUDDEN'S ATROPHY METHOD: AND A SUMMARY OF ITS RESULTS

BY

E. C. SEGUIN, M.D.

CORRESPONDING MEMBER OF THE "VEREIN FUR INNERE MEDICIN" OF BERLIN

[Reprinted from the ARCHIVES OF MEDICINE, Vol. x, Nos. 2 and 3, 1883]

G. P. PUTNAM'S SONS

NEW YORK: 27 & 29 WEST 23D STREET

LONDON: 25 HENRIETTA STREET, COVENT GARDEN

1883

With regards of
E. C. Seguin

GUDDEN'S ATROPHY METHOD: AND A SUMMARY OF ITS RESULTS.

By E. C. SEGUIN, M.D.

MUCH as we honor the discoverer of a new fact of importance or of a series of facts, we owe much more to him who places at our disposal a new method, one sufficiently tried to merit adoption at our hands. A method is a chapter of applied logic, pregnant with possible results of unknown importance. And this is not its only value, for, as a part of the logic of science, it also serves a purpose in scientific speculation, and almost inevitably gives rise to new ideas, to other methods, by analogy or by deduction.

Gudden's atrophy method, one of the anatomical methods applied to the study of that obscure field of research—the central nervous system,—lay hidden, most unfortunately, in the possession of its originator and a few pupils, for nearly thirty years, and even since its publication in 1872, it has been but little noticed outside of a very small circle of neurologists.[1] Yet, I think that the following abstract will show it to be one of the most important and promising of the various special anatomical methods.[2]

From 1850 to 1852 Augustus Waller was at work in Budge's laboratory at Bonn, perfecting his method of studying the degeneration of severed nerves. The facts of degeneration and regeneration after nerve-section had been long known, but it remained for Waller to formulate the

[1] In the most recent scientific work on anatomy (Burt G. Wilder and Gage, "Anatomical Technology," New York, 1882), containing a remarkably full bibliographical index, the name of Gudden does not appear.

[2] The special anatomical methods applied to the study of the central nervous

Reprinted from the ARCHIVES OF MEDICINE, Vol. x, No. 2, October, 1883.

law under which the degenerative process occurs. In his "*Nouvelle méthode anatomique*," Bonn, 1852, he gave a full summary of the facts and laws he had discovered, and they have been common property ever since, leading to numerous important anatomical and pathological discoveries. The doctrine of the Wallerian degeneration, has, I may say, been a valuable instrument in our hands for thirty years.

At the very same time, 1849, Gudden, a recent graduate of the University of Berlin, then assistant physician in the Siegburg insane asylum under the celebrated Jacobi, was experimenting upon the brains of animals in a different, yet correlative, manner. He had already extirpated eyes of rabbits, and noted the atrophy of the intracranial optic apparatus; he already knew the tractus peduncularis transversus, and many of his subsequent discoveries were half developed.[1] This was done in ignorance of Waller's work, and partly before it; certainly long before Türck's publications on secondary degenerations.

For reasons best known to himself, Professor von Gudden did not publish an account of his method until 1870,[2] although his principal facts and laws had long been known to him, and he had communicated freely with friends and assistants, so that we have here a striking example of the simultaneous discovery of facts, laws, and methods which, applied to the same division of the animal frame, are in themselves not very unlike, and in their results are logically united, and, indeed, complementary to each other.

system are: (a), The dissociation or dissection of fasciculi in partially hardened specimens, as practised by older anatomists, by Foville, Gratiolet, Broadbent, and many others (nearly disused); (b), the Rolando-Stilling method of series of fine sections of the hardened organs; (c), the Wallerian degeneration in animals; (d), the Türck secondary degenerations in man (and in animals); (e), Flechsig's method of determining the period at which certain systems of fibres in the fœtus acquire myelin.

[1] Oral communication from Prof. v. Gudden, August 4, 1883.

[2] Experimentaluntersuchungen über das peripherische und centrale Nervensystem. *Wesphal's Archiv*, Bd. ii, p. 693.

I purpose in the following pages to enunciate the central principle of Gudden's method, and then to analyze his publications and those of his pupils, more or less in chronological order with reference to publication. Besides consulting these publications, I have had the advantages of conversing with Prof. Gudden and several of his pupils, and of examining the specimens proving the statements advanced in nearly every case.

PRINCIPLE: *That by experimenting on newly-born animals, especially those which, like the rabbit, are brought forth in a somewhat fœtal state, complete atrophy of the central connections of a nerve-trunk, or a nerve-fasciculus, or a nerve-centre, is obtained by operation. The central (proximal) fibres and cells are destroyed, while the peripheral fibres, if any, undergo the Wallerian degeneration.*

There are several secondary advantages in using very young animals; they (rabbits at least) have almost no hair; they suffer but little pain, and scarcely struggle under the knife; they bear the shock of incision and removal of important parts of the central nervous system wonderfully well; hæmostasis is in them very rapid and definite, and the process of repair simple.

For operations on nerve-trunks, almost any animal can be used. For experiments on intracranial parts, dogs are objectionable because of their hard craniums; kittens are intermediate between rabbits and dogs in this respect, but they are liable to suppuration, and the mother is apt to interfere with the sutures.

Most operations should be done on the second or third day of life, but may succeed later; still, the older the animal the more the Wallerian law of degeneration in one direction (centrifugal from centre) only prevails.

For most operations on the olfactory apparatus it is

necessary to wait until the animal (rabbit) be six or seven days old, in order to give time for the ears (hearing and tactile sense) to develop sufficiently to enable the creature to guide itself and find the mother.

For operations on the hypoglossal and vagus nerves one must wait still longer, from the second to the sixth week.[1]

The various operative procedures will be described under the several heads of this review, but it is well to state here that the lesion should be a *destructive* one; the olfactory lobe or eyeball must be removed, or in the case of nerves, their central ends after section must be pulled out of their bony canals with good forceps. In the case of nerves in newly-born animals, so much comes away by this method that there is reason to believe that some axis-cylinders are broken off deep in the nervous centre from which they spring.

It is possible that some of Gudden's operations give results as much by degeneration as by simple atrophy; in other words, that his and Waller's method overlap each other. In this connection let me say that the histology of the early period of Gudden's atrophy is unknown, which is a deplorable hiatus in our knowledge. From a study of this point we may learn something of the obscure point referred to, viz., the true relation between the two methods, and obtain new light on so-called "trophic" laws of the nervous system.

The operated animals are left to the mother's care, and allowed to grow from six to twelve weeks; the former period being quite sufficient for most experiments. Indeed, Gudden has shown[2] that after removal of one eyeball in dogs one day old, distinct atrophy of the optic nerve was

[1] Oral communication from Prof. v. Gudden.

[2] *Archiv f. Ophthalmologie*, Bd. xxv, Heft 4, pp. 237–246, 1879.

visible on the 8th, 14th, and 28th days. In rabbits a distinct atrophy may be visible in 36 hours after operation on second day.[1]

During this period of preservation, the animals should be carefully studied as to their functions, with especial reference to the injured apparatus, and compensatory functions. By doing this in as careful a manner as Munk has done for his cortex experiments, some physiological and psychological knowledge might be gained from each series of operations. This has been done, but not as fully or exactly as should be.

After the animals are sacrificed, the affected parts should be carefully examined for asymmetry, change in color and consistence. If possible, photographs of the fresh specimens should be taken, and careful measurements of parts made. The organs are then placed in a solution of bichromate of potassium, or of osmic acid, for hardening. When this is complete the various sections necessary to reveal the direction and extent of central changes are made and preserved in accordance with well-known methods. It is often desirable to have complete series of sections through the whole organ or a portion of it, so as to enable the exact extent and distribution of the atrophy to be followed. In such cases the use of Gudden's microtome is necessary. The sections should be thin enough to allow of their examination by $\frac{1}{5}$ or $\frac{1}{8}$ inch objectives. Usually trans-sections show the lesion well, but in some cases (olfactory part of anterior commissure) longitudinal dextro-sinistral sections are necessary.

The condition of the atrophied centres may be roughly stated as follows: As an example, after extraction of the facial nerve, a series of trans-sections of the medulla show simply an absence, a total absence, of the injured nerve-

[1] *Ibidem*, Bd. xxv, Heft 1, pp. 1–56.

trunk in its course through the medulla, and of its nucleus of origin. There is, architecturally speaking, a virtual void in this region, which is filled up or compensated to a degree by the ingrowth and overcrowding of adjacent normal parts. There are no exudations, thickening of neuroglia, areas of disintegration, etc., so that the topographical study of the sections and the tracing out of the atrophy are not hindered as in ordinary pathological specimens.

RESULTS OBTAINED BY GUDDEN'S METHOD.

I propose mentioning these very briefly and without criticism. Many of the questions to which the experiments relate are novel and intricate; further researches by other methods may modify the views held by Gudden and his pupils, but these views should be plainly stated so as to serve as data for other observers. Enough will be found in this abstract to justify, I think, the statement that we already owe much in anatomy and physiology to this method, and that it offers great possibilities for the future.

The topics will be considered partially in chronological order.

I.—Composition and connections of the commissura anterior cerebri.

Von Gudden and Ganser have been able to resolve these two questions in greater part by the atrophy method. It has long been known that the C. A. consists of two unequal fasciculi, variable in different animals, and these Ganser calls (1) pars temporalis; (2) pars olfactoria. In general terms, as revealed in normal sections, the p. t. is very much larger in man and in monkeys, while in lower mammals, particularly the hedgehog, mole, and rabbit, the p. o. is highly developed and larger than the p. t.

1. Pars temporalis. Von Gudden, in 1870,[1] published experiments illustrating the nature of the pars temporalis.

EXPT.—In a newly-born rabbit the whole upper part of one cerebral hemisphere was excised, above the basal ganglia. Autopsy at eight weeks showed the commissura anterior normal.

EXPT.—In another rabbit the whole of one hemisphere was removed. Seven weeks later the animal was killed, and sections of the (hardened) brain showed complete atrophy of the commissura anterior. The external capsule was, however, preserved in the remaining hemisphere.

In both experiments there was atrophy of the corpus callosum, complete in the latter.

Conclusions: the temporal division of the C. A. is a true commissure, as is also the corpus callosum.

The external capsule has no direct connection with the C. A.

These experimental results have been confirmed by Ganser. The conclusions are, moreover, supported and extended by the result of the careful study of complete series of brain sections of man, monkey, and lower mammals, made by Ganser.[2] The sections were transverse and horizontal, and in them the course of the C. A. (its pars temporalis) was always distinctly into the temporal lobe, beyond the nucleus amygdalus. No fasciculi going to other parts of brain (occipital lobes, Meynert et al.) could be discovered.

2. Pars olfactoria. Von Gudden experimented on this also, but his conclusions were invalidated by a source of error discovered later on. It is to Ganser (op. cit.) that we owe the absolute demonstration of its true nature and distribution by means of von Gudden's method.

[1] Experimentaluntersuchungen über das peripherische und centrale Nervensystem. *Westphal's Archiv*, Bd. ii, p. 693, experiments v and vi.

[2] S. Ganser: Ueber die vordere Commissur der Säugethiere. *Westphal's Archiv*, Bd. ix, Heft 2, 1878.

Expt.—The brain of two rabbits formerly operated by von Gudden were cut into complete series of horizontal and transverse sections. The injury consisted in destruction of the left tractus olfactorious and frontal part of lobus pyriformis with a portion of adjacent (dorsal) frontal lobe. The left bulbus olfactorius (lobus olf.) was very much atrophied. In both sets of sections (the horizontal best adapted) there was complete absence of the olfactory division of the C. A.

Expt.—Two other rabbits from whom von Gudden had removed one of the bulbi olfactorii. These brains were shrunken and overhardened, yet fairly good sections were obtained, enough to show that in these two cases also there was complete atrophy of the p. ol. of the C. A.

Conclusions: the pars olfactoria of the C. A. is also a true commissure, and unites the two bulbi olfactorii.

Thus, by a few simple experiments and careful observations (objectively carried out) of preparations, is that fanciful fabric, Meynert's olfactory chiasma overturned.

II.—Commissura inferior cerebri.

Almost from his earliest experiments on the optic apparatus, von Gudden had observed that after removal of both eyeballs, a portion of the chiasma and of the optic tracts did not undergo atrophy. In his first published accounts [1] of the structure of the optic nerves, etc., he formulated this observation by naming the surviving or non-atrophied nervous band, commissura inferior cerebri, and expressed the opinion that it was a commissure between the thalami. In the first of his series of contributions [2] in *Græfe's Archiv*, these preliminary demonstrations are repeated. In the third contribution,[3] in reply to certain statements of Michel,

[1] Experimentaluntersuchungen über das peripherische und centrale Nervensystem. *Westphal's Archiv*, Bd. ii, p. 693 (1870).
Sitzung der viii Versammlung der Schweitzarischen Irrenærzte (Sept., 1872), abstract in *Psychiatrische Zeitschrift*, Bd, xxx, p. 135.

[2] Ueber die Kreuzung der Fasern im Chiasma Nervorum Opticorum. *Archiv f. Ophthalmologie*, Bd. xx, Heft 2. pp. 249–268, 1874.
The second contribution is in Bd. xxi, Heft 3, pp. 199–205, 1875.

[3] *Idem*, Bd. xxv, Heft 1, pp. 1–56, 1879.

he insists upon the distinction between this fasciculus and the one known as Meynert's commissure, which is distinctly dorsal of the chiasma, and separated from it. The commissura inferior, on the contrary, is mingled with the tractus opticus and can only be discerned by excluding the fibres of the latter, which is easily done by removal of both eyeballs in the young animals, thus producing atrophy of all the truly optic fasciculi.

Sometimes in the rabbit, dog, and cat, a slight depression in the caudal-ventral aspect of the chiasm suggests its limits.

In trans-sections of rabbits' tractus opticus no special limit is discernible; but it is noticed that while the optic fibres are coarse, those of the C. I. are fine. If one of these trans-sections be treated with alcohol and then with carmine the portion belonging to the C. I. is strongly tinged, while the optic fibres remain white. The same reaction has been obtained by Mayser in the T. O. of cyprinoid fishes. In dogs, cats, monkeys, and man no such chemical distinction exists. If the sections of rabbits' T. O. are placed unstained (only colored by potassium bichromate) in glycerine, the fibres of the C. I. appear as forming a clearer mass in the dark field of the optic fibres.

In his fourth optic contribution,[1] von Gudden describes the appearance of the optic apparatus in a human case of long-standing one-sided blindness. Those parts in the chiasma and tractus optici which correspond to the C. I. he found unchanged, but not distinctly limited, and made up of fibres having the same diameter as the optic fibres. The C. I. in these trans-sections was dorsal of the optic fibres. In the chiasma of animals it occupies the caudal, or the caudal-ventral, aspect.

In his "Experimentaluntersuchungen," he states, that

[1] *Archiv f. Ophthal.*, Bd. xxv, Heft 4, pp. 237–246, 1879.

the study of numerous trans-sections of the brain has shown that the commissura inferior extends into the thalami optici, connects them, and is probably in no wise associated with the optic apparatus. After destruction of the lobus opticus and the corpus geniculatum laterale, the commissura inferior remains unchanged.

In connection with these important studies upon the commissural systems of the brain (corpus callosum, commissura anterior, and commissura inferior) von Gudden has formulated the following law of atrophy (of nutrition):

That a true commissure, separated from one of its attachments, must undergo bilateral atrophy.

III.—Distribution of fibres in the optic apparatus.

As stated in the four articles in *Græfe's Archiv*, von Gudden has reached the following conclusions:

1. That in birds there is complete decussation of fibres in the optic chiasma.

Expt.—Removal of one eyeball in a pigeon immediately after birth. Autopsy in eight weeks showed atrophy of optic nerve of same side, extending across the woven chiasm to the opposite optic lobe, which is much reduced in size.

2. In the higher mammalia the decussation is variable, but is always a semi-decussation.

Expt.—In a rabbit,[1] the right eyeball was enucleated. Results: (*a*) atrophy of right optic nerve; (*b*) chiasma unchanged; (*c*) opposite (left) tractus opticus ~~swollen~~, as are also (*d*) the lobus opticus, and (*e*) the corpus geniculatum laterale; (*f*) complete atrophy of opposite left tractus peduncularis. Negative results: post-optic lobes (corpus quadrigeminum inf.) and commissura inferior normal.

This experiment seemed to show that there was complete

[1] It was always in newly-born animals that the various operations were done.

decussation in the rabbit, and so Gudden held for some years, but different experiments, published in 1879,[1] demonstrated beyond question the existence of a direct fasciculus in the optic nerve of this animal.

Expt.—By means of a sharp spoon, the optic lobe, corpus geniculatum externum, subjacent part of caudex, and corresponding optic tract are removed. Autopsy at age of six months. Results : (*a*) total atrophy of injured tractus opticus ; (*b*) opposite optic nerve atrophies in greater part, but still showing a small normal white fasciculus.

Expt.—The brain was lifted up, and one half of chiasm cut out with a sharp spoon. Results : complete atrophy of the optic fibres, except a small (lateral) bundle in opposite optic nerve—its direct fasciculus—(in this experiment the commissura inferior undergoes atrophy, as does also Meynert's commissure dorsal of tractus).

As complementary to these results may be added the fact that one of Gudden's assistants, Dr. Bumm,[2] carefully examined the retina of the eye receiving only the direct fasciculus, and found the nerve-fibre layer atrophied, except in the lateral (temporal) segment of the organ. The retina was hardened in osmic acid, and the whole of it cut and prepared.

Consequently, it must be held as demonstrated that in rabbits there is semi-decussation, but to a slight degree only, as the crossed fasciculus is enormously larger than the direct ; and that this small direct fasciculus supplies the temporal part of the retina in ~~dogs~~

Expt.—Right eyeball enucleated. Results : (*a*) complete atrophy of right optic nerve ; (*b*) both optic tracts reduced in size, the left smaller ; (*c*) both optic lobes smaller ; (*d*) both corpora geniculata laterala smaller ; (*e*) caudal ~~cords~~ of thalami smaller ; (*f*) tractus peduncularis smaller. The commissura inferior was preserved.

Expt.—" Optic centres " (lobus opticus and corpus genicu-

[1] *Arch. f. Ophthal.*, Bd. xxv, 1, pp. 1–56, 1879.

[2] Bumm : Ueber die Vertheilung des Sehnerven in der Netzhaut des Kaninchens. *Westphal's Archiv*, Bd. xi, p. 264, 1881.

latum laterale) removed on right side. Results : (*a*) tractus opticus of same side atrophied ; (*b*) both optic nerves reduced in size, opposite (left) smaller ; (*c*) commissura inferior preserved.

In dogs, consequently, there is also semi-decussation, to a greater extent than in rabbits, but still the direct fasciculus is smaller than the crossed.

The course of the direct fasciculus in the dog (as seen in horizontal sections of chiasm from above experiment), lies in the dorsal border of right tractus opticus ; reaching the chiasm it passes over the crossed fasciculus from the other tractus, and then from the medial border of the optic nerve on same side (right). In rabbits this fasciculus lies in the lateral border of optic nerve.

Numerous experiments of these kinds are recorded in the various papers, and elaborate measurements given of the areas of the affected optic nerves and tracts.

Gudden formulates the law of atrophy in the optic apparatus as follows :

1. The optic nerves and tracts degenerate (undergo atrophy) when the retina is destroyed (removed).

2. The "optic centres" (lobus opticus and corpus geniculatum laterale) also undergo atrophy in such a case.

3. When the centres are removed, the degeneration does not involve the retina.

In man, reasoning by analogy from the higher mammals experimented on it, would seem that semi-decussation were a logical necessity, yet several advocates of complete decussation have appeared.[1] These arguments have, however, been very weak, and Gudden made short work of their few experimental claims.[2] Cases of long-standing monocular blindness in man, fitted for the direct solution of the problem, are not infrequent, but few of them have been properly

[1] Chiefly Michel, *Arch. f. Ophthal.*, Bd. xxiii, Heft 2, pp. 213-226, 1877.

[2] *Arch. f. Ophthal.*, Bd. xxv, Heft 1, pp. 1-56, 1879.

studied. Von Gudden has had the opportunity of examining four such cases.

Case 1.—Man eighty-five years old; blind in one eye from early youth: phthisis bulbi. The atrophy is not total, many normal nerve-fibres being found in affected optic nerve. Both tractus smaller than normal.

Case 2.—Man thirty years old; complete atrophy of left optic nerve (not one fibre found in a careful microscopic examination); both tractus reduced in size, one on opposite side smaller.

Case 3.—Male, dying at sixty, with left hemiplegia. Thirteen years previously had had an attack of "apoplexy." Besides the lesion in one internal capsule explaining the hemiparesis, there was found an old hemorrhage which had destroyed the left corpus geniculatum laterale, part of the thalamus opticus, and part of the tractus opticus. The whole tractus was atrophied; the opposite optic nerve smaller, and the nerve on same side contained many atrophied fibres, and was smaller (on section) in its medial and central fasciculi. (The case is obscurely reported, and there seems to be an error in the designation of the optic nerves.)

Case 4.[1]—Woman, aged seventy-three years. Glaucoma and complete loss of sight in right eye for four years. The right optic nerve was completely atrophied; the right tractus opticus seemed normal to naked eye; the left tractus was smaller and mostly gray; on the chiasma itself, and upon the left tractus, crossing chiasm from the frontal medial border of left optic nerve, was a projecting white band, the direct fasciculus from left eye. The microscope showed the left tractus all gray except in its dorsal aspect, where some normal nerve-fibres were seen; the right tractus, on the other hand, presented (in sections) only a small area of atrophied fibres (the direct fasciculus from the right eye, and the commissura inferior). The degeneration and atrophy extend to the optic centres, *i. e.*, the left corpus geniculatum laterale and lobus opticus.

These cases certainly favor the theory of semi-decussation.

The following is a general summary of von Gudden's results with respect to the optic apparatus.

1. That Johannes Müller's law (which was only a physiological postulate), that in animals whose visual axes are

[1] *Arch. f. Ophthal.*, Bd. xxv, Heft 4, pp. 237–246, 1879.

only lateral (monocular vision) there is total decussation, and that in animals whose visual axes are more or less directed forward (more or less perfect binocular vision) there is semi-decussation, is a good law, supported by his (Gudden's) experiments and other facts.

2. That there is no anterior commissural (inter-retinal) fasciculus in the optic apparatus.

3. That the posterior commissural fasciculus of classic authors is his commissura inferior, which has no relation to the optic system.

4. That the optic system in mammals consists only of two bundles or fasciculi, one crossed and the other direct; the former the larger in rabbits, dogs, and cats (and quite certainly in man).

5. That there is an accessory optic fasciculus, whose central and peripheral terminations are yet unknown, viz., the tractus peduncularis transversus.

6. That each optic tract is composed of three sorts of fibres, of the same size in man, of different sizes and different carmine reaction in animals; optic fibres (crossed and direct), fibres of the commissura inferior, and "hemispheric fibres," whose course is not well known. These last-named fibres are in the most lateral part of the tractus and pass into the crus cerebri.

These results were confirmed by the experiments of von Gudden's pupil—Ganser—on cats, published last year.[1] This able observer has also carried the inquiry further, as regards the cortical and retinal distribution of optic fibres, affording a remarkable concurrence between von Gudden's results and Munk's.

Ganser chose cats, for several reasons. They are vigorous under operative interference; they are more intelligent

[1] Ueber die periphere und centrale Anordnung der Sehnervenfasern und über das Corpus bigeminum anterius, *Westphal's Archiv*, Bd. xiii, Heft 2, 1882.

than rabbits, so that one can test their visual field; they have, to a remarkable degree, binocular vision, and thus resemble man; their retina has a very high and clearly defined structure, thus affording excellent opportunity for ophthalmoscopic and microscopic study.

He relates three crucial experiments as follows:

Expt. 1.—For the determination of the direct fasciculus. On the third day after birth, the left eyeball of a kitten was enucleated. A fine forceps was introduced through the foramen opticorum, and the tractus opticus of the same side torn or cut (at the same time unintentionally a slight wound was made in the infundibulum and left internal capsule). Cat recovered quickly and grew normally; was, however, lazy or stupid, more so than a brother kitten who had lost one hemisphere. Vision seemed good till tested, when it was found it had hemianopsia, *i. e.*, was using only the temporal half of its remaining retina. Autopsy at nine months. The only part of optic apparatus left was a white nerve extending from right eyeball to the optic centres of same side; no chiasm. Right optic lobe and corpus geniculatum laterale larger. The right tractus peduncularis transversus was smaller than normal, the left almost invisible; commissura inferior absent. Sections of the hardened retina showed normal nerve-fibres (amyelinic in cat), only in its temporal two thirds; on nasal side fibres and ganglionic bodies atrophied.

Conclusion: there is a true fasciculus lateralis (or direct fasciculus) in the optic system of the cat, and it supplies the temporal part of the retina.

Expt. 2.—To determine the relation between the occipital cortex and the optic apparatus.

In a kitten of same litter a portion of the left occipital lobe was removed without wounding the cornu ammonis or the basal ganglia. The injury was smaller but similar in location to that done to a dog's brain by von Gudden.[1] This cat had no symptoms, but special tests (by means of a white ball swung around the cat in direct and inverse directions) revealed right homonymous hemianopsia. Ophthalmoscopic examination showed

[1] *Archiv f. Ophthal.*, Bd. xxi, Heft 3, pp. 199–205, 1875.

morbid changes in the temporal two fifths of the left retina, and in the right eye more than the medial (nasal) half was atrophied. Autopsy at nine months. Left hemisphere shows scar opening freely into lateral ventricle (no inflammatory action). Left tractus opticus smaller than right, revealing more of Meynert's commissure on the crus. The optic nerves seemed little, if at all, changed to the naked eye, but on measuring the area of sections under the microscope, the right nerve-sections were found smaller.

Microscopic examination of the hardened retinæ showed no local elemental atrophy, but there was distinct thinning of the retina in both left halves (left temporal and right nasal halves), especially distinct in the papillæ.

EXPT. 3.—For the same purpose. In a third kitten the left hemisphere of the cerebrum was nearly all removed, the corpus callosum and fornix being carefully cut in the medial line. The animal grew well and was not at all paralyzed. The only movement which he learned late was springing up on a chair, etc. Was dull and had a bad memory. Tactile sensibility and reflex movements seemed normal, but pricking was but little felt over whole body. As in the former cat, there was right homonymous hemianopsia. Ophthalmoscope showed the temporal part of retina atrophied in left eye, while in the right the morbid changes extended over two thirds of the retina (more than nasal half). Autopsy at six months. Large serous sac in left brain ; olfactory bulb and lobe, base of temporal lobe, and basal ganglia uninjured ; left thalamus smaller ; internal capsule atrophied ; left half of pons, and left crus cerebri smaller ; left anterior pyramid absent ; left optic centres (optic lobe and corpus genic. laterale) are smaller. Both tractus optici smaller than those of normal kittens of same age ; left more reduced. Under microscope the section-areas of both optic nerves diminished, right more. Sections of hardened retinæ showed, as in former case, a thinning of retinal layers in both left halves—left temporal and right nasal segments.

Conclusions: In cats the crossed fasciculus is larger than the direct. In cats there is an anatomical connection between the hemispheres (visual area in occipital lobe) and the optic centres, extending thence to the retinæ.

Gudden's old experiment,[1] showing that in rabbits re-

[1] Experimentaluntersuchungen, etc. *Westphal's Archiv*, Bd. ii, p. 693, 1870.

moval of one hemisphere has no influence on optic nerves, was repeated with the same results in six young rabbits.

It would thus appear that in lower mammals (those with insignificant binocular vision) the optic-nerve fibres are chiefly collected in the optic centres (optic lobe and corpus geniculatum laterale), while in higher mammals, dogs, cats, monkeys, as in man, there is a large, better differentiated cortical connection.

The new and most interesting question of the anatomical relation existing between the layers of the optic lobes and the peripheral optic apparatus on the one hand, and the visual area of the cortex cerebri on the other hand, was studied in the rat as follows:

Expt. A.—White rat three days old. Right eye enucleated. Autopsy at nine months. Right optic nerve atrophied; left tractus much smaller than right; left optic lobe and corpus geniculatum laterale flatter and smaller.

Expt. B.—White rat three days old; removal of convex part of right cerebral hemisphere (part of cornu ammonis also removed). Autopsy in nine months. Both optic nerves alike; right thalamus, optic lobe, and corpus geniculatum a little smaller. Right internal capsule atrophied, crus cerebri smaller, anterior pyramid absent.

The brains were subdivided into segments and hardened in a two-per-cent solution of osmic acid (24 hours), and later in alcohol. The optic lobes were cut into fine trans-sections, which were carefully examined.[1]

In rat A there was a reduction of the left superficial gray, and nearly total atrophy of the superficial white (*fibre visiva* of Tartuferi[2]); intermediate white normal on both sides. [Effects—one-sided in rat because of insignificance of direct fasciculus.]

In rat B, on the right side, the intermediate white was reduced, and there was also partial atrophy of the right side of the tubular gray (from what cause?).

[1] In the normal optic lobe Ganser distinguishes the following layers: 1. zonal fibres (present only in higher mammals); 2. superficial gray; 3. superficial white; 4. intermediate gray; 5. intermediate white; 6. deep-seated white; and 7. the tubular gray.—Ganser: Vergleichend-anatomische Studien über das Gehirn der Maulwurfs. *Morphol. Jahrbuch*, Bd. vii, p. 711.

[2] *Fibre di origine del tratto ottico* in the *strato bianco-cinereo superficiale* of

Conclusions: In rats the peripheral optic apparatus is more intimately connected with the superficial gray and white layers of the optic lobes, while the visual area of the cerebrum is mostly in relation with the intermediate white layer.

It may not be wholly superfluous to add that an important negative conclusion from the work of von Gudden and his pupils is, that neither the post-optic lobes (corpora quadrigemina inferior) nor the corpora geniculata medialis are connected with the optic apparatus; a view which is borne out by morphological conditions, etc.

IV.—Tractus peduncularis transversus.

When von Gudden published his first account [1] of this interesting fasciculus he was unaware that it had long been known; but he himself rectified his error by giving a bibliographical account of it along with his later experiments.[2] The bundle was unknown to most of the older anatomists, but Gall and Spurzheim[3] described and figured it in several plates as early as 1810. Von Gudden knew it (in connection with his first optic experiments) as early as 1849. In Leuret and Gratiolet's atlas[4] it is drawn by the artist but not referred to by the author (Gratiolet). An Italian investigator appears to have described it in 1861, under the name of *fascio transverso.*[5]

Tartuferi. (Sull' anatomia minuta dell' eminenze bigemine anteriori delle scimmie. *Rivista Sperimentale di Freniatria*, v, F. iii, 1879.

[1] Ueber einen bisher nichbeschreibenen Nervenfaserung im Gehirn der Säugethiere und das Menschen. *Westphal's Archiv*, Bd. ii, p. 364,—1870.

[2] Ueber den tractus peduncularis transversus. *Westphal's Archiv*, Bd, xi, Heft 2, 1880.

[3] "Atlas d'anatomie et de physiologie du système nerveux en général et du cerveau en particulier." Paris, 1810.

[4] "Anatomie comparée du système nerveux." Paris, 1857.

[5] A proposal has recently been made by a distinguished American zoölogist, Wilder, "Anatomical Technology," New York (1882), to change this name to *cimbia*. This term has no anatomical sense whatever its architectural value may be. Von Gudden's name, on the contrary, if long, is descriptive and

As its name correctly implies the tractus ped. trans. traverses the crus cerebri (peduncularis). It apparently arises from just within the medial border of the crus, passes over it in a line about half-way between the caudal edge of the tractus opticus (and Meynert's commissure) and the frontal border of the pons, extending laterad and dorsad to the frontal edge of the lobus opticus where it disappears. The tractus ped. tr. is thus distinctly traceable only in the lower mammalia; in man it is but slightly visible in a part of its course.[1]

Von Gudden has endeavored, but thus far in vain, to determine the true origin and destination of this fasciculus. As regards its function he long ago learned something from his various extirpation experiments on the optic apparatus. The facts have already been incidentally stated, but a more direct quotation is permissible.

Expt.—Extirpation of both eyes in rabbit. Results: atrophy of optic nerves, of optic part of chiasm and tractus optici, of primary optic centres, *and of both tractus pedunc. tr.*

Expt.—Extirpation of one eyeball in rabbit. Results: atrophy of optic nerve, of opposite optic tract (very slight of tract of same side), of primary optic centres of opposite side, *and of tractus pedunc. tr. of opposite side.*

Expt.—In the dog after enucleation of one eyeball there are: atrophy of optic nerve, of both optic tracts, and both sets of primary optic centres, *and of both tractus pedunc. tr.* In all the parts caudad of chiasm the atrophy is more marked on the side opposite the enucleation.

Expt.—Excision of part of occipital lobe in a dog, and removal of one optic lobe in a rabbit, were followed, among other results, by reduction in size of the corresponding tractus pedunc. tr.

Conclusions: The tractus peduncularis transversus has a

equivalent to a definition—consequently it is good and should be retained. From the context in Wilder, *op. cit.*, § 1203, p. 475, it seems that he does not know Gudden's now old discovery of the optic nature of this fasciculus.

[1] *Cf.* Schwalbe: "Lehrbuch der Neurologie," p. 459. Erlangen, 1881.

functional and anatomical connection with the optic apparatus—more with its peripheral part, to which it stands in the same relation as the crossed fasciculus of the tractus opticus. Its connection with the primary optic centres is direct, but less intimate; its connection with the visual area of the cerebral cortex is still less marked, but also direct.

GUDDEN'S ATROPHY METHOD: AND A SUMMARY OF ITS RESULTS.

(*Second Paper.**)

By E. C. SEGUIN, M.D.

(*With two wood-cuts.*)

DURING the month of October of this year I went to Munich specially to see Professor von Gudden's preparations illustrating the various propositions advanced in this analysis, and he very kindly showed them to me himself with the greatest patience and system. I must also thank Dr. Ganser for his courteous assistance in the laboratory, more especially with respect to details as to various points of *technique*.

Before proceeding to continue the enumeration of Gudden's and Ganser's discoveries, it is necessary to insert corrections and additions relative to two topics treated of in the first paper.

First,[1] as to the pars olfactoria of the commissura anterior. Professor von Gudden has recently been led to return to his former view (against Ganser), that this commissure does not unite the *bulbi* olfactorii, but the *lobi* o. To understand the experimental results, one must have a clear idea of Gudden's view of the anatomy of the rabbit's olfactory bulb. He considers the true bulb structure to sit like a cap over the projected extremity of the lobus olfactorius; in other

* *Vide* ARCHIVES for October, p. 126. [This paper should have appeared as editorial matter, but was placed among original papers because the editorial space had been engaged.—ED.]

[1] Unpublished.

Reprinted from the ARCHIVES OF MEDICINE, Vol. x, No. 3, December, 1883.

words, a portion of cerebral cortex is inclosed within the bulb proper. Consequently it is impossible to remove the bulbus olf. without also injuring or removing a portion of cerebral cortex and white substance.

EXPT.[1]—The lobus olfactorius is simply separated by incision from its connections with the brain. The skull is not opened, and no nervous substance removed. Autopsy shows that the separated bulbus, though smaller, has retained its vitality, and the olfactory nerves are normal. Trans-sections and horizontal sections give the following results :

In the bulbus there is no positive atrophy of its essential elements. In the olfactory lobe of the cerebrum (inferior part of frontal lobe) there is distinct though slight atrophy, in size and number, of ganglion cells in the cortex. In the centre of the bulbus (inclosed cerebral substance) the white substance is much atrophied. The tractus olfactorius shows much atrophy of its white substance, more especially the lateral fibres.

Contrary to Ganser, the pars olfactoria of the C. A. is to a great extent preserved. Some fibres are atrophied (absent), viz.: those which in the normal state extended into the intra-bulbar projection of the olfactory lobe, which was cut off by the incision.

Consequently von Gudden holds that the pars olfactoria of the commissura anterior connects two lobi olfactorii, a view which is just as much opposed to Meynert's hypothesis as the former was.

Second, an addition to the anatomy of the optic apparatus. Last year[2] von Gudden presented to the Science Congress at Eisenach a *résumé* of more recent experiments upon the various constituents of the optic apparatus. He repeated his demonstrations that the commissura inferior cerebri and the hemispheric fasciculus of the tractus opticus (*vide* ARCHIVES OF MEDICINE, October, p. 139) are not directly connected, physiologically, with the visual apparatus.

[1] To save repetition it is to be understood, unless specially otherwise stated, that the experiments cited in this paper are made upon newly-born rabbits, which are allowed to live many months before autopsy.

[2] Ueber die verschiedenen Nervenfasernsysteme in der Retina und im Nervus opticus.—*Tageblatt der* 55 *Versammlung der Deutschen Naturforscher und Aerzte*, Eisenach, 1882.

He laid the results of new experiments before the Association with reference to :

1. The relations of the hemispheres to vision. If one hemisphere, even inclusive of its corpus striatum, be removed from a newly-born rabbit, it is impossible, after the animal has become adult, to detect any impairment of sight ; and both the pupils react normally. Gudden does not generalize from this fact ; he simply advances it as true in rabbits. He calls attention to a possible explanation of the conflict between this result and Munk's conclusions, by the fact that Munk always operated on adult animals (or, at least, not on the newly-born) whose cerebrum has acquired certain functional attributes absent at an early period of life.

2. Centre of pupillary movements. He condemns as erroneous his former statement, that after removal of one lobus opticus the opposite was abnormal.

(*a*) If one successfully removes the superficial layers of one lobus opticus with a sharp spoon, it is observed that the animal is absolutely blind in the eye opposite the lesion, but the pupils are both normal in appearance and movements. Post-mortem examination shows that the optic nerve opposite the lesion is reduced in size, but is white and contains normal fibres. The retina shows a general diffuse reduction in the number of its nerve fibres. The tractus ped. transversus on the operated side is normal. On careful examination one sees a little latero-frontad of the injured lobus opticus a small eminence, more prominent than on the opposite normal side. The eminence is rendered more distinct by partial atrophy of fibres of the tractus opticus.

(*b*) If, in a newly-born rabbit, we remove one lobus opticus, together with the above-described eminence, the adult animal shows blindness of the opposite eye with wide dilatation of its pupil—a dilatation which is only slightly af-

fected by the strongest daylight. The optic nerve and retina are as described *supra*, but the tractus peduncularis trans. on the operated side is completely atrophied.

Thus two "centres" are demonstrated: one in the lobus opticus, for vision; the other a little frontad of it, for reflex pupillary movements.

3. The corpus geniculatum laterale is a third "centre," probably a trophic centre for the optic tract and nerve, since after its removal these parts undergo atrophy just as after enucleation of one eyeball [except that the direct (lateral) optic fasciculus remains normal in the former case]. The various experiments bearing upon this question are not yet complete.

4. If portions of one lobus opticus be removed, there are found various segments of localized retinal atrophy (in contradistinction to the diffuse atrophy noticed after removal of the whole lobus opticus). Experiments upon this further differentiation of nerve fibres are in progress.

5.[1] Within a year Gudden and Ganser have been successful in dividing the optic chiasm longitudinally by passing a long narrow-bladed knife through the unopened skull and brain at the vertex.

Results: Complete atrophy of crossed fasciculi of optic chiasm, with preservation of the lateral fasciculi. Commissura inferior atrophied bilaterally.

I pass on now to studies in other regions of the nervous centres, continuing the enumeration begun in the former paper.

V.—Demonstration of the pyramidal tract.[2]

In 1871, soon after the publication of Hitzig's first experiments on the cerebral cortex, von Gudden removed the

[1] Unpublished.

[2] Ueber Dementia Paralytica.—*Correspondenzblätt f. Schweizer Aerzte*, Bd. ii, p. 79, 1872.

frontal portion of one hemisphere (including the "motor centres") in newly-born rabbits. Preparations from the adult brain showed atrophy of the corresponding crus cerebi and anterior pyramid. The date of this experiment is noteworthy; it was certainly anterior to Flechsig's publications,[1] and is the first demonstration of the continuity of the motor or pyramidal tract from the cerebral cortex caudad. The experiment has since been repeated on the dog with even more striking results. Specimens from the dog I was able to examine. They showed, caudad of the atrophied cerebral area, a complete absence of the medial division of the crus cerebri, of the pyramidal fasciculi in the pons, and of the pyramid strictly speaking. Below the decussation the atrophy can be traced in the postero-lateral column of the opposite side. The anterior columns are unchanged. The lemniscus (*schleife*) is also much atrophied on the operated side (compare statements in paragraph on fasciculus ad tegmentum, *infra*).

VI.—Connections of the cerebellum.[2]

EXPT.—In a newly-born rabbit one half of the cerebellum was removed. At the autopsy of the adult animal it was found that a very small part of the lateral portion of the hemisphere remained attached to the medulla.[3] A full series of trans-sections was made and studied. Results:

1. In the upper cervical region complete atrophy (absence) of the fasciculus ad cerebellum[4] (*Kleinhirnseitenstrangbahn* of Flechsig) on the same side as the lesion.

2. In the caudal part of the medulla, we find likewise on the same side as the injury: (*a*) atrophy of a group of cells lying ventral in the medulla ("nucleus of anterior columns"), and of

[1] Yet Flechsig, in his most recent publication ("Plan des Menschlichen Gehirns," p. vii, note; Leipzig, 1883), still claims the demonstration as his.

[2] Ueber die Verbindungsbahnen des kleinen Gehirns.—*Tageblatt der* 55 *Versammlung der Deutschen Naturforscher und Aerzte*, im Eisenach, 1882.

[3] It was also found that one post-optic lobe was much injured, and that the corresponding crus cerebri had been touched by the spoon.

[4] I would propose this term, fasciculus ad cerebellum, for the ascending cerebellar fasciculus. It is in harmony with the names of adjacent centripetal bundles, viz., the fasciculus cuneatus and the fasc. gracilis.

(*b*) a second cell-group lateral in the medulla but ventrad of the trigeminal root, the so-called "nucleus lateralis," from its supposed connections with the lateral columns. In this region the fibræ arciformes which go to form the beginning of the corpus restiforme are absent.

d. Sections further frontad in the medulla show atrophy of another nucleus on the same side as the injury, one situated dorsad of ascending root of N. v. At level of N. vii there is complete absence of the corpus restiforme.

4. In the various sections of the medulla it is seen that the olive of the side *opposite* the lesion is almost wholly atrophied; a small part of it is still seen in the caudal sections, and probably its survival is due to the bit of cerebellum which was left in the operation.

5. Sections in the region of N. viii, and further frontad, show a normal state of this nerve, of the upper olives, trapezium, and of the (falsely) so-called "external auditory nucleus," or Deiters' nucleus. The inner division of the processus ad medullam is about normal; while, as already stated, its outer portion, or corpus restiforme, is totally (?) atrophied.

6. Sections through the upper part of the pons Varolii show absence of processus ad pontem, without atrophy of trapezium or of upper olives. It is exceedingly difficult to determine the connections of the atrophied fibres, but many of them were certainly in the opposite half of the pons, a few in the corresponding half, and others were true commissural fibres.

7. Sections further frontad show absence of the processus ad cerebrum on the operated side. The cells of the descending root of N. v are absent. Further on the nucleus tegmenti of the opposite side is almost entirely atrophied. The few cells remaining are to be considered as evidence that another fasciculus probably arises from the nucleus tegmenti and proceeds frontad. That this survival of a few cells is not due to incomplete decussation of the processus ad cerebrum is shown by the absolutely normal state of the other nucleus: were there a semi-decussation, both nuclei would exhibit atrophy. The preserved cells of the nucleus tegmenti are large, and are situated laterad of roots of N. iii. Further frontad the number of cells in both nuclei tegmenti become equal.

Consequently it may be stated that:—

1. The processus ad medullam (or corpus restiforme) has

four origins, viz.: in three cell-groups or nuclei on the same side in the medulla oblongata, a dorsal, a lateral, and a ventral nucleus[1]; it is also derived from the olive of the opposite side.

2. The processus ad pontem arises chiefly from cells in the opposite half of the pons. It does not give fibres to the pyramidal tract. Prof. Gudden does not consider his researches on this point concluded.

3. The processus ad cerebrum proceeds frontad, as is well known, and wholly decussates with its fellow, and has its cell-connections in the caudo-medial part of the opposite nucleus tegmenti.

VII.—Connections of the processus ad cerebrum.

In 1881, my friend, Prof. A. Forel, of Zürich, presented to the German Science Congress at Salzburg the results of a most interesting experiment upon this organ.[2]

Expt.—In a newly-born rabbit the right processus ad cerebrum, the right side of velum medullare anterius, post-optic lobe, and (involuntarily) a small bit of the right processus ad pontem were removed.

Results: Atrophy of remaining (caudad and frontad of wound) fibres of processus ad cerebrum. The atrophy is easily traced frontad across the median line to the left nucleus tegmenti, which is largely atrophied, more especially in its caudal part. Sections frontad of nuclei tegmenti show no lesions. The ventral decussation of the tegmentum (*ventrale Haubenkreuzung*) is slightly unequal on the two sides.

But it is in the sections caudad of the injury that the most interesting fact is found.

The right half of the vermis superior is extremely atrophic; some fasciculi going to the nucleus dentatus are visibly atrophied. The nuclei (dentatus, dectiformis, embolus), as well as the corpus restiforme, are perfectly normal.

[1] This last was known to Deiters as an origin for fibres for the corpus restiforme, and Prof. Gudden has called it Deiters' nucleus; but as this term has been more generally applied to the remarkable group of large cells which are in seeming relation to the acoustic nerve, he will abandon the name.

[2] Sitzungsberichte der 54 Versammlung Deutschen Naturforscher und Aerzte, im Salzburg, 1881. In *Wiener med. Zeitung*, No. 46, 1881.

Other lesions noted are: In consequence of the removal of the post-optic lobe, there is a reduction in the volume of the right lateral lemniscus (*Schleifenschicht*) as far caudad as N. vii. Further caudad no lesions. There is slight atrophy of the so-called crus of the post-optic lobe as far frontad as the corpus geniculatum mediale, which seems normal. The only change in the lobi optici is a very slight reduction of the deep white layer on the right side. The r. descending root of N. v is almost entirely absent, a few cells remaining at the level of the exit of the nerve. N. viii is normal, as is also the fountain-like decussation (*Fontaineartige Kreutzung* of Forel) in the tegmentum, which Meynert and Wernicke would associate with N. v.

The important conclusion drawn from this experiment is that the processus ad cerebrum arises in the vermis superior of one side, and terminates (wholly?) in the nucleus tegmenti of the opposite side.

VIII.—Central connections of the sciatic nerve.

This subject has been studied by means of Gudden's method by his pupil and assistant, Mayser.[1] He gives a detailed account of the histology and architecture of the rabbit's spinal cords. Then he takes up the study of some cords from which the sciatic nerve had been separated immediately after birth, two by extraction of roots, and one by section of the nerve.

The lesions found in the spinal cord are similar in nature and general distribution, but more extensive and distinct in the cases of extraction.

Results: *White substance.* The only marked change is in the posterior columns of the lumbar enlargement, which are reduced in size on the same side as the injury. The fasciculus cuneatus is alone atrophied, and this lesion gradually diminishes in the dorsal region. In my examination of the specimens I observed in the lumbar region com-

[1] P. Mayser: Experimentaller Beitrag zur Kenntniss des Baues des Kaninchen-Rückenmarks. Inaugural Dissertation.— *Westphal's Archiv für Psychiatrie*, Bd. vii, Heft iii, 1877.

plete absence of the posterior root zone on the injured side. The posterior part of the lateral column is also very slightly reduced in size.

The *gray substance* shows the greatest atrophy. At level of greatest lesion, the anterior gray horn is much reduced in size, and has lost its quadrangular shape, and is barren of ganglion cells. Higher up the postero-lateral group of cells is preserved, especially in the cord of the animal whose sciatic had been simply divided. Some ganglion cells on the side opposite the injury, those sending cylinder-axis processes toward the commissura anterior, must have perished, for they are fewer in number than the same cells on the injured side (evidence of crossed origin of some fibres of sciatic). The posterior horn on the injured side is about one third smaller than normal; still it contains many small ganglion cells, and the difference is mainly in the fibre-system. The substantia gelatinosa is much atrophied, but shows only a small reduction in the number of its cells. The two commissures are reduced in size, the posterior more so.

Essentially similar lesions were found in the cervical spinal cord of a rabbit whose brachial plexus had been extracted.

IX.—Nuclei of the cranial nerves.[1]

From personal examination of specimens.

NN. iii and iv. EXPT.—Extirpation of the eyeball in a newly-born rabbit, with careful extraction of orbital nerves.

Result: Atrophy in various parts of optic apparatus, as described *supra;* complete atrophy of NN. iii, iv, and vi. Series of trans-sections enable us to study the deeper atrophy of the nuclei of these nerves.

[1] Prof. v. Gudden has made no systematic publication of these valuable results. Here and there in his papers he refers to the facts which have long been known to him; many prior to 1872, as shown by their citation in Kondracki's Zürich thesis.

1. N. iii.[1] Nucleus in well-known location, caudad of lobus opticus and dorsad of fasciculus longitudinalis posterior. By Gudden's method the nucleus is made out to be triple.

(*a*) A fronto-ventral nucleus lying upon the fasc. long. post., and giving origin to fibres which pass ventrally in a straight direction.

(*b*) A caudo-ventral nucleus, partly dorsad of (*a*), overlapping it somewhat, but also extending (in its caudal part) down to the fasc. long. post. This cell-group also gives rise to direct vertical fibres.

(*c*) A caudal nucleus lying dorsad of (*b*), not reaching the level of the fasc. long. post., and separated from the nucleus of N. iv by a distinct barren interval. This contains and gives origin to decussated and horizontally coursing fibres.

In a normal preparation, a horizontal section made just dorsad of the fasc. long. post. shows cells of nuclei (*a*) and (*b*) and cross-cut nerve fibres. One made further dorsad, passing through nucleus (*c*), shows cells and mostly horizontally running nerve fibres.

Similar sections from an animal experimented upon as described above show: the ventral section, absence of fibres and cells on the same side as the injury; the dorsal section, on the contrary, exhibits atrophy (absence) of cells and horizontal fibres on side opposite the injury.

The decussation of the fibres of N. iii occurs mostly by the lateral fibres of the root, which pierce the ventral nuclei, then turn pretty sharply mediad and decussate with their homologues to connect with cells in the dorsal nucleus of the opposite side. A few fibres decussate to reach this nucleus through the raphe. The large majority of the root-fibres of N. iii, constituting the medial roots, arise from (*a*) and (*b*) and pass out directly.

[1] *Vide* a short communication in Mittheilungen der Morphol.-Physiol. Gesellschaft zu München, in *Münchner Aerztlichen Intelligenzblätt*, 1883.

Prof. von Gudden anticipates that by a better method of extirpation of single ocular muscles with their attached nerve filaments, we may yet be able to define a greater differentiation of cell-groups in the oculomotor nuclei. In this connection it is well to mention that in studying the atrophied N. iii nuclei, the displacement produced by atrophy of the two ventral nuclei on the side of the injury must be borne in mind. In consequence of the virtual void thus caused, the dorsal nucleus is displaced downward or ventrally, and the fasc. long. post. in a dorso-mediad direction. Prof. Gudden has long ago appreciated and called attention to this source of error in studying sections from regions atrophied by his method. We will see other illustrations of this further on (*vide* corpus mammilare and von Monakow's researches on the thalamus).

2. N. iv. Its nucleus lies caudad of the caudal nucleus of N. iii, and extends down to the fasc. long. post. In pathological brains, sagittal, horizontal, and trans-sections show that the atrophy involves only one nucleus, always the one on the side opposite the injury. Consequently N. iv has a simple origin, and its root-fibres wholly decussate.

3. N. v.[1] Two series of preparations were shown me: 1. Trans-sections from the nerve centres of a rabbit whose trigeminus on one side had been cut between the pons Varolii and the ganglion Gasserii; the operation was done by the old intracranial method, and was not entirely successful. In the sections, a partial atrophy of the ascending root can be traced frontad from a point between the second and third cervical nerve to the level of exit of root. The descending root and its peculiar cells also show marked atrophy. The motor nucleus and root are, on the contrary, well preserved. 2. Series of trans-sections from the nervous centres of a calf presenting extensive malformations and atrophies of the brain.

[1] Unpublished.

The principal lesions presented by this brain, as exhibited in a drawing of its basis, were: (1) absence of right olfactory nerves and tractus (bulb partly preserved); (2) complete absence of both optic nerves and tractus, with preservation of the commissura inferior; (3) partial atrophy of right N. iii; (4) preservation of both NN. iv; (5) root of right N. v seems totally atrophied, while its ganglion and peripheral branches are preserved; (6) absence of both NN. vi; (7) preservation of both NN. vii and of the other nerves caudad

Sections from the level of second cervical nerve to that of lobus opticus examined: On the right side there is complete absence of the ascending (spinal) root of N. v throughout its entire extent. The motor nucleus and root are likewise completely absent. Of the descending root a few cells exist, and a few fibres from them can be traced caudo-ventrad toward the exit region of nerve-trunk.

From these specimens (and others) Gudden is willing to recognize only three roots of the trigeminus, two sensory and one motor. The other roots, as given by Meynert and others, he regards as imaginary.[1]

4. N. vi. Expt.—Described in paragraph on N. iii. Trans-

[1] In this connection it may be interesting to refer to von Gudden's numerous and ingenious experiments on the question of the trophic function of the trigeminus. Some of these are already quite old and are cited by Kondracki in his thesis in 1872 (E. Kondracki: Ueber die Durchschneidung des Nervus trigeminus, Zürich), but although better than Snelling's they are unknown. He admitted the fact that after section of the trigeminus ulceration of the cornea and other changes of nutrition occurred in the eye. He took newly-born rabbits and caused adhesion of the lids by operation (artificial ankyloblepharon). When this was entirely healed he cut the trigeminus by the intracranial method. Opening the lids ten or fifteen days later he invariably obtained normal corneæ. Consequently he held the eye-lesions following section of N. v to be traumatic in origin. More recently (oral communication) von Gudden has operated by cutting the optic nerve behind the eyeball with the least possible injury to other parts within the orbit. In this operation the ciliary nerves are cut, and besides blindness there is anæsthesia of the cornea. But the lids retain their sensibility and by reflex action continue to protect the eye from injury and dirt; the cornea remains clear. Kondracki also refers to operations on peripheral nerve-trunks after which, by care and cleanliness, the skin of the foot remained free from the falsely so-called trophic changes. Gudden was not aware that long before Brown-Séquard had demonstrated facts like the last, showing ulcerations after nerve-sections to be traumatic.

sections show complete absence of trunk of nerve in the medulla, and total atrophy of the cell-group laterad of genu of facial nerve.

In the calf's brain above described, while the facial nerves and nuclei are well preserved, there is no trace of the fibres and nucleus of NN. vi. In neither case do any cells remain.

Consequently the origin of the abducens nerve is simple and direct.

5. N. vii. EXPT.—In the newly-born rabbit the facial nerve is extracted from the Fallopian canal. If the operation is well done a long piece of the nerve is brought away.

Results: Complete absence of extra- and intra-bulbar root of nerve on operated side; the ventral aspect of the medulla is a little flattened. Sections show absence of root-fibres; the site of genu is vacant, and no cells can be found in the so-called "lower nucleus," the three-grouped nucleus (rabbit) in the ventral aspect of the medulla. On the other hand, the nucleus under the genu of the nerve, near the floor of the fourth ventricle, is absolutely normal; comparison with a normal nucleus shows that no cells are absent.

Consequently the facial nerve has only one nucleus—in opposition to the teaching of nearly all anatomists who have seen fibres of this nerve arise from the nucleus under its genu. Even so recent an authority as Spitzka[1] elaborately describes this double origin of N. vii.

In estimating the full value of this experiment, the result of operation upon N. vi must also be borne in mind: the two experiments mutually support one another, and their agreement (in a large number of experiments by Gudden and several of his pupils) renders an error extremely unlikely.

6. N. viii. As yet it has been impossible to complete an experiment upon this nerve, because of the severe rotatory movements and death by exhaustion which follow its section or extraction. Still, some important negative conclusions have been reached indirectly. First, it has no

[1] Contributions to Encephalic Anatomy, pp. 85–87, *Journal of Nervous and Mental Disease*, April, 1880.

connection with the so-called external auditory or Deiters' nucleus, for a proof of which statement see Monakow's experiment on corpus restiforme, p. 258; second, in Gudden's removal of one cerebellar hemisphere, the nerve and its nucleus were perfectly normal.

7. N. x.[1] Expt.—Extraction of central end of nerve and its ganglia in rabbits.

Results: Atrophy of well-known sub-ependymal nucleus, dorso-laterad of nucleus of hypoglossus. There is also complete atrophy of a group of large cells lying ventrad of intra-bulbar root of the nerve, and mediad of the so-called nucleus lateralis (which, as shown *supra*, is one of the origins of the corpus restiforme.) The tri-neural fasciculus (Spitzka's good name for the "*gemeinschaftliche aufsteigende Wurzel des seitlichen gemischten Systems*" of Meynert) is also decidedly atrophied on the operated side.

8. N. xi. A number of apparently successful extraction experiments have been made on this nerve, but the brains have not yet been cut.

9. N. xii.[2] Expt.—Extraction (extra-spinal) of the hypoglossal in a rabbit from five to eight days old.

Results: Complete atrophy of the cells of the sub-ependymal medial nucleus of hypoglossus, and absence of intra-bulbar rootlets. In the series of sections which I examined, there remained a few fibres and cells of the most caudal part of the nucleus, from a slight incompleteness in the operation. The ganglion cells dorsad of the atrophied nucleus, those of the opposite hypoglossal nucleus, and the olives, were perfectly normal.

Hence the origin of this nerve is simple and direct.

These results are very instructive. They show, in an apparently convincing manner, that nearly all the cranial nerves have a much simpler origin than most anatomists —especially those who allow physiological considerations to warp their observation—describe. Yet the one nerve which nearly all observers describe as having a simple direct origin—N. iii—is conclusively proved by most beautiful experiments to have a highly complex nucleus,

[1] Unpublished.

[2] *Idem*, but referred to briefly in several papers.

and to arise by both direct and crossed fibres. Even if we are not prepared to admit that these experiments of von Gudden absolutely settle the question of the origin of the cranial nerves, yet the results are sufficiently clear and constant, it seems to me, to merit the attention of anatomists, and to serve in some measure as a control upon the mere study of sections from normal nerve centres.

X.—Fasciculus longitudinalis posterior.

There are no experiments directly bearing upon this part, but from a consideration of some of the specimens above referred to and some others, important negative conclusions can be reached.

It is generally taught by anatomists that this fasciculus is directly connected with the nuclei of the motor cranial nerves, more especially those of NN. iii and iv, serving perhaps as a means of associating or coördinating their action. That this is not so, that it is an example of hypothetical anatomy, is shown by the following facts.

1. In sections exhibiting atrophy of NN. iii and iv, the fasc. long. post. are of equal and normal size, even when one is displaced somewhat, as in atrophy of the oculomotorius.

2. In the mole, whose entire optic apparatus, including NN. iii and iv, is undeveloped and as good as absent, there is a well-developed fasc. long. post.

XI.—Ganglion interpedunculare.[1]

This ganglion is a distinct external protuberance in rabbits, cats,[2] and dogs ; in the monkey (Hapale), and in man it lies concealed in the wall of the foramen cœcum, but is

[1] Gudden : Mittheilungen über das Ganglion Interpedunculare.— *Westphal's Archiv*, Bd. xi, Hft. 2, 1880.

[2] This part is not named, figured, or indexed by Wilder, *op. cit.* "The ventral origin of the fasciculus Meynerti was jointly discovered by Gudden and Forel prior to 1872, but not by Gudden's method."

not to be confounded with the substantia perforata posterior. It consists mainly of small round or spindle-shaped ganglion cells, the smallest of which are very similar to "nuclei" of the neuroglia. It also contains some angular ganglion cells. The little nests described by Forel (Haubenregion, *Westphal's Archiv*, Bd. vii, p. 393) are really made up of most delicate amyelinic nerve fibres.

In horizontal sections of normal rabbit's brain, the G. I. lies caudad of the foramen cœcum, between the lemnisci (Schleife). From its frontal extremity issue the two fasciculi Meynerti, and laterad of these are cross-sections of bundles of N. iii, and longitudinal sections of the pedunculus corporis mammillaris (*vide infra*). A little frontad and quite laterad of the foramen cœcum are cross-sections of the tractus peduncularis transversus.

EXPT.—Removal of one ganglion habenulæ in a rabbit a few days old.

Results: Complete atrophy of corresponding fasciculus Meynerti, of its point of entrance into ganglion interpedunculare, and of the ganglion itself on both sides of the median line. No atrophy of cells observed. It is not stated whether fibres of origin of fasc. M. decussate or not in the ganglion, but from the illustration accompanying the article, it would seem that they did.

XII.—The corpus mammillare.[1]

Von Gudden describes the external appearance and general configuration of the C. M. in rabbits, cats, dogs, monkey (Hapale), and in man. Each animal presents some difference in external configuration of C. M. The rabbit presents lateral accessory eminences, which are the lateral ganglia.

Microscopic examinations (trans-sections), however, show that in all animals there are two sets of nuclei, a medial and a lateral on either side.

[1] Gudden: Beitrag zur Kentniss des Corpus Mammillare und der sogenannten Schenkel des Fornix.—*Westphal's Archiv*, Bd. xi, Hft. 2, 1880.

1. The lateral ganglion of C. M. It contains large ganglion ~~walls~~. From its lateral part arises a fasciculus, the pedunculus corporis mammillaris. In the rabbit this fasciculus lies mediad of crus cerebri; most N. iii fibres pass out through it. The ganglion interpedunculare and the beginning of fasciculus Meynerti lie mediad of the ped. corp. mam. It tends dorso-latero caudad to enter the pons Varolii. The columnæ fornicis lie mediad of it. It almost joins the lemniscus (Schleife), but can be distinguished from it by:

(*a*) Its larger-sized nerve fibres, which can be traced ventro-laterad of the lemniscus, through the trapezium, into the medulla oblongata, as far caudad as the olives.

(*b*) By any experiment which causes atrophy of the pyramidal tract (*vide* p. 238), such as removal of the frontal part of the brain, or of one hemisphere. On examining trans-sections from such a case, one can trace, caudad of the commissura anterior, atrophy of the fine fibre system of the lemniscus, as well as of the pyramidal tract proper on the side of the injury. The large fibres of the ped. corp. mam. ventro-laterad of the absent lemniscus, between it and the site of the pyramidal tract, are, however, preserved. In passing through the trapezium (never ventrad of it), it becomes more medial and approaches its fellow: in the trapezium the fibres are somewhat scattered, but caudad of it they once more unite to form a compact bundle lying dorsad of the pyramid (which is mostly made up of fine fibres). In the region of the olives the fasciculus tends more dorsad and is lost.

Conclusion: the lateral ganglion of C. M. is unconnected with the hemisphere.

2. Medial ganglion, made up of smaller cells. Two fasciculi arise from it, viz., the fasciculus Vicq D' Azyr (Meynert's radix ascendens of columna fornicis) and the fasciculus ad tegmentum (*Haubenbündel*).

(*a*) Fasciculus ad tegmentum. *Vide* special paragraph, p. ~~257~~ 23

(*b*) Fasciculus Vicq D' Azyr.

Expt.—After removal of one hemisphere (rabbit) this fasciculus and the medial ganglion of C. M. undergo partial atrophy. Refers to illustrations by Cruveilhier, Van der Kolk, and other, of unsymmetrical (atrophied) human brains showing atrophy of one of the two eminences of the C. M.

Expt.—Removal of one hemisphere and of the frontal part of the thalamus.

Results: Complete atrophy of fasc. Vicq D' Azyr and of the ventral part of medial nucleus of C. M.

Conclusion: The fasc. Vicq D' Azyr arises from the ventral part of the medial ganglion of C. M., and, extending dorso-frontad (in rabbit), is distributed to the nucleus anterior of the thalamus (tuberculum anterius). There it also enters into indirect connection with fibres of the corona radiata, which extend to the cortex cerebri (to vicinity of motor area, according to Von Monakow's experiments—*vide infra*).

XIII.—Connections of the columnæ fornicis.[1]

Expt.—Removal of one hemisphere and section or removal of both Ammon's horns.

Results: Trans-sections show complete atrophy (absence) of both columnæ fornicis; the fasciculus Vicq D' Azyr is reduced in size on the side of absent hemisphere.

Expt.—Removal of one hemisphere without injury to cornu Ammonis.

Results: Columnæ fornicis normal; fasciculus Vicq D' Azyr somewhat reduced in size on operated side.

Expt.—Incision of one hemisphere and section or laceration of fimbria on one side dorsad of commissura anterior.

Results: Disappearance of columnæ fornicis on operated side; very slight reduction in size of fasc. Vicq D' Azyr.

Dr. Ganser's Expt.—After removal of one eyeball, a fine

[1] Beitrag zur Kenntniss des Corpus Mammillare und der sogenannten Schenkel des Fornix.—*Westphal's Archiv*, Bd. xi, Hft. 2, 1880.

forceps was introduced through the foramen opticum in the direction of the chiasm, with the intention of destroying the tractus opticus on one side. Besides this, however, a slight cut was made in the tuber cinereum which severed one columna fornicis.

Results : Complete atrophy of injured columna fornicis frontad of corpus mammillare ; caudad the atrophy could be traced behind the C. M. to the point where the col. fornicis decussates with its homologue (*vide* next section) to the side opposite the injury, in the central gray matter. The fasc. Vicq D' Azyr were normal.

These experiments show that the columnæ fornicis enter into the formation of (are continuous with) the fimbria, fornix, and cornu Ammonis.

They also prove in the most positive manner that there is no continuity between the columnæ fornicis and the fasciculi Vicq D' Azyr, and that these fasciculi do not form a genu or loop in or around the corpus mammillare, as claimed by Meynert.[1]

XIV.—Composition of the columnæ fornicis.

This is much more complex than is taught in works on nervous anatomy, and an approach to an exact solution has only been reached by von Gudden within the last year, after a study of many years, embracing the performance of numerous experiments.

To Ganser, his very able and ingenious collaborator, we owe the first and principal step in this series of discoveries, viz.: the experimental determination of the passage of the columna fornicis *through* the corpus mammillare (contrary to all previous writers, who taught that it arose from the C. M.), and of its origin further caudad and dorsad, in the central gray surrounding the third ventricle.

In 1880[2] von Gudden published an article upon the corpus mammillare and columnæ fornicis, in which he claimed the demonstration of two additional fasciculi of the columna

[1] Stricker: "Manual of Histology," Am. ed., pp. 691–2, fig. 269. New York, 1872.

[2] *Op. cit.*

fornicis, besides the well-known bundle studied by Ganser. In the past year he has found still a fourth bundle in this system, but has not made the discovery public. Consequently, instead of giving an abstract of the paper of 1880, I shall give a *résumé* of what Prof. Gudden demonstrated to me, and of his explanations.

He now considers the so-called columna fornicis (*Fornixsäule*) consist of four fasciculi, viz.:

1. A ventral crossed fasciculus.
2. A dorsal " "
3. A dorsal direct fasciculus.
4. A ventral " "

1. The ventral crossed bundle is the one long known as the columna fornicis in its passage through the tuber cinereum to the corpus mammillare (Meynert's radix descendens fornicis). Its true origin and course were discovered by Ganser in 1878 by an experiment described on p. 253. The origin he found to be in the central gray near the third ventricle, but not from any distinct cell-group. In most animals these fibres of origin are scattered, and their course is difficult or even impossible to make out, but in rabbits (with a few individual exceptions), in mice, and moles the fibres are aggregated into considerable fasciculi, so that carmine, gold, and osmic preparations exhibit distinct pictures. As seen in the typical rabbit the fine bundles coming from the central gray run ventro-frontad; they are mediad of the fasciculi Meynerti. At a point caudad and dorsad of the medial ganglia of the corpus mammillare these fine bundles completely decussate; they now form a large fasciculus on either side, which curves around the medial ganglion of the C. M., passes frontad between it and the lateral ganglion. It apparently issues from the frontal aspect of the C. M. into the tuber cinereum, takes a direction dorso-latero-frontad to a level dorsad of the commissura anterior,

where it enters into the formation of the root of the fornix.

2. The dorsal crossed bundle joins No. 1 at a point frontad of the tuber cinereum. It is demonstrated by the previously cited experiment of removal of one hemisphere and of its cornu Ammonis without injury to the root of the fornix (region where columnæ fornicis enter fornix). In a series of trans-sections from such a brain, one sees, as stated *supra*, that fasciculus No. 1 is completely absent caudad of C. M. in it, and in the tuber cinereum ; but in the sections frontad of this point, at the level of the commissura anterior, a bundle of transversly-cut nerve fibres is seen close to the site of the atrophied columna fornicis—just mediad of it. These fibres are pale ; they have taken up much less carmine than those of the normal fasciculus No. 1 on the opposite side. Still further frontad, over the commissura anterior, these fibres diverge toward the median line, cross it, and enter the fornix of the opposite non-operated side. Indeed, without special preparation, after this experiment, by turning what remains of the fornix over frontad, it is easy to see with the naked eye a fasciculus passing from the normal half of the fornix ventrad toward the median line. In the sections it is also evident that this fasciculus (No. 2) is absent in the column opposite the injury, while its main bundle (No. 1) is present.

3. The dorsal direct bundle is made evident by Ganser's experiment of wound in the tuber cinereum p. ~~253~~ 119. The inferior fasciculus (No. 1) is absent on one side in the sections, but dorsad of the commissura anterior there appears near the site of the absent bundle a round section of fibres. These can be traced caudad in the series of sections ; it spreads latero-dorsad, describing a curve with convexity outward, to reach the dorso-lateral part of the thalamus, where it *seems* connected with a cell-group. It may, however, have an origin at a point further ventrad in the curve,

where there is a nest of larger cells. In this course the fibres of fasciculus No. 3 enter into the formation of the stratum zonale. As seen dorsad of the commissura anterior its fibres are smaller than those of fasciculi 1 and 2. After removal of one Ammon's horn it undergoes atrophy on the same side as the injury. If von Gudden were sure that this fasciculus (No. 3) ended in the above-mentioned cell-group in the thalamus, he would call it the *thalamic root of the fornix*, but he now prefers to call it the dorsal direct bundle.

4. The ventral direct bundle.[1] After Ganser's experiment, in sections through the tuber cinereum, two or three little stained fasciculi (cross-cut) are seen to join the columna fornicis, or on the operated side to tend toward its site. Their ultimate course frontad is unknown, but it is certain that they undergo atrophy on the same side as the injury when the cornu Ammonis is removed on one side. Caudad the small bundles can be traced in a direction ventro-medio-dorsad into the central gray matter frontad of corpus mammillare: a distinct nucleus has not been observed.

Prof. v. Gudden believes that bundles 1 and 4 contribute to form that part of the fornix which lies under the corpus callosum and is known as the longitudinal fornix. Bundles 2 and 3 diverge and take a dorso-laterad course in the fornix.

The tænia thalami crosses bundle No. 3, passes caudad of it without giving it any fibres. This is distinctly seen in such atrophy preparations as involve atrophy of the entire columna fornicis; the cross-section of the tænia has the same diameter on either side. Neither have any of the preparations afforded evidence of a connection between the columna fornicis and the stria cornea.

[1] Unpublished.

XV.—Fasciculus ad tegmentum (Haubenbündel).[1]

This was partly described by Prof. von Gudden in his paper on the corpus mammillare (1880). He then correctly described its course, but its true origin, and more especially its termination in a distinct ganglion in the tegmentum, were not discovered until this year, and I have the privilege of first making the facts public.

Origin of the fasciculus. In sections from a rabbit which had undergone removal of one hemisphere together with the anterior part of the thalamus, the fasciculus Vicq D' Azyr is completely absent on the operated side, and the medial ganglion of the corpus mammillare to a great extent atrophied. However, one sees in the transsections, a fasciculus arising from the remains of the medial ganglion of the corpus mammillare; it extends a little way dorsad, then turns abruptly ventro-caudad to enter the tegmentum.

In a very successful (*i.e.*, in the right plane) horizontal section from a normal rabbit brain the horizontal course of the fasciculus can be traced a long way. In the frontal part of such a preparation are the commissura anterior and cross-sections of the columnæ fornicis; then, proceeding caudad, in the median line the slit-like opening of the third ventricle; on either side of this a large bundle is seen in cross-section, the fasciculus Vicq D' Azyr; from this a bundle of fibres diverges caudad, tending toward the median line; it passes mediad of another large bundle seen in cross-section, viz.: the fasciculus Meynerti; a little further caudad it lies mediad of the emerging roots (cross-cut) of N. iii, and finally is lost very near the median line, just ventrad of the fasciculus longitudinalis posterior.

The exact caudad connection (termination) of the fasc. ad tegmentum was ascertained by the following experiment.

[1] Unpublished.

By passing a very delicate knife vertically through the corpus callosum to the base of the brain, the chiasm and one medial ganglion of the corpus mammillare were divided. [Ganser's experiment of injury to medial ganglion by passing a forceps through the foramen opticum in a kitten also afforded a similar demonstration.] The study of transsections from these two cases showed the following results in parts caudad of the injured ganglion. There was no trace of the fasc. ad tegmentum on the side of the injury, and this atrophy could easily be traced as far back as a point a little caudad of N. iv, ventrad of the fasc. long. post. Then on the normal side is a beautiful well-defined cell-group, of which there is no trace on the side of the absent fasciculus. Both in the cat and rabbit the demonstration of this new ganglion was most conclusive.

Now that the terminal cell-group is known it is easy, in horizontal trans-sections from normal brains, to trace the fasc. ad tegmentum all the way from its origin to its termination.

Observing more closely the mode of origin of the (conjoined) fasc. ad tegmentum and the fasc. Vicq D' Azyr, by means of numerous series of sections, von Gudden has recently discovered that the medial ganglion of the corpus mammillare is composed of two distinct cell-groups or nuclei: a dorso-frontal nucleus which gives origin to the fasc. ad tegmentum, and a ventro-caudal mass from which springs the fasc. Vicq D' Azyr. This constitutes an addition to our knowledge of the corpus mammillare, as stated on p. ~~250~~.

I propose the term fasciculus ad tegmentum for the German noun *Haubenbündel.* This has Prof. Gudden's approval.

XVI.—Corpus restiforme and Deiters' nucleus.

Dr. C. von Monakow, assistant physician of the asylum of

St. Pirminsberg, in Pfäfers, near Rǫgatz, has carried on a number of most interesting researches by Gudden's method. He has more especially occupied himself with the cortex cerebri and basal ganglia, a field not specially entered upon by Gudden. He also made one experiment upon more peripheral parts,[1] which it is best to analyze immediately after Gudden's studies.

Dr. Monakow gives an historical account of Deiters' nucleus, or the so-called external acoustic nucleus.

Expt.—In a newly-born rabbit, left hemi-section of the spinal cord, just below the decussation.

Physiological results: Complete left hemiplegia with nearly complete recovery later. At first little reaction to needle-pricks on both sides of body, but later was more marked (though incomplete) on the left side. State of face not specially stated.

Autopsy in six months.

Gross changes: Hemi-section not quite complete; a part, inner half, of fasciculus gracilis (Goll's column) and a small part of the anterior column remain. Evident ascending degeneration in medulla. Left side of cord smaller caudad of section. Left vermis superior cerebelli flatter.

Microscopic examination of sections as far frontad as thalamus.

(*a*) Changes frontad of injury: (1) Complete atrophy of fasciculus cuneatus and its nucleus; (2) partial atrophy of fasciculus gracilis and its nucleus; (3) complete atrophy of fasciculus ad cerebellum; (4) corpus restiforme reduced one half, atrophied chiefly in its medial part; (5) the atrophy of the nucleus of the fasc. cuneatus is by far more marked in its lateral mass, which can be traced to the caudal level of N. viii roots (the medial nucleus is reduced one third without evident histological changes); (6) the inner division of the processus ad medullam (or ascending N. viii of Roller) is but slightly altered—at level of true N. viii roots it is smaller on the operated side, because of absence of fibres coming to it horizontally from corpus restiforme; (7) at this level the large cells of Deiters' nucleus are nearly all lost on the same side as the injury, more especially in its latero-dorsal aspect—this atrophy blends with that of the adjacent corpus restiforme—the

[1] Monakow, Experimenteller Beitrag zur Kenntniss des Corpus Restiforme, des "ausseren Acusticuskerns," und deren Beziehungen zum Rückenmark.—*Westphal's Archiv*, Bd. xiv, Hft. 1.

acoustic root-fibres which apparently arise from this nucleus are seen perfectly intact in the wasted nucleus—all these roots are normal and equal on the two sides; (8) in the cerebellum the atrophy can be indistinctly traced into the vermis superior, whose cortex and medulla are certainly less developed than on the healthy side; (9) the left nucleus lateralis is almost wholly atrophied (*vide* ¶ vi, on origin of processus ad medullam); (10) the left formatio reticularis in its lateral part is generally reduced and poorer in cells, a condition which can be traced as far frontad as the lobus opticus; (11) the pyramid opposite the injury is slightly smaller, but after a short distance frontad this atrophy ceases; (12) the prolongation of the lemniscus (*Schleife*) in the medulla is slightly atrophied on the same side as the injury. No changes in lobi optici or beyond; these were particularly searched for, as Monakow's principal idea in making the experiment was to trace an ascending atrophy to the brain.

(*b*) Changes caudad of the injury: Complete atrophy of pyramid below hemi-section, on same side of course.

The perfectly normal parts of medulla are the medial part of formatio reticularis, the fasc. long. post. (continuation of anterior column?), the upper olives, and all the nerve nuclei and roots. The lower olive on the operated side is a trifle smaller on the operated side, and the same is true of the ascending root of N. v, but the word atrophy can hardly be applied.

Conclusions: 1. That the processus ad medullam (*vide* ¶ vi) is made up of several bundles: of the processus ad cerebellum (*Kleinhirnseitenstrangbahn*), fibræ arcuatæ, fibres from both olives and the formatio reticularis, and largely in its medial portion of fibres derived from the fasciculus cuneatus through its lateral nucleus.

2. This last portion of the atrophied corpus restiforme can be traced to a connection with the large cells of Deiters' nucleus.

3. Deiters' nucleus is certainly not connected with the acoustic nerve.

4. The atrophic fasciculus ad cerebellum is in relation with the caudal part of the vermis superior (compare p. ~~239~~ on connection of processus ad cerebrum, with frontal part of vermis, as shown by Forel).

The most important result of this experiment is that concerning the relations of Deiters' nucleus. With singular unanimity it is considered by anatomists as the outer acoustic nucleus, because they have traced root-fibres of N. viii into it. So recent an authority as Spitzka[1] not only admits it as a nucleus of N. viii, but declines to consider the usual division into an internal and external nucleus. If any anatomist could see, as I have seen, the N. viii fibres absolutely normal in the area of Deiters' nucleus while almost all the cells were absent, he would begin to reflect on the uncertainty of the simple study of normal sections, however carefully or conscientiously carried out. The annals of encephalic anatomy are replete with the errors due to exclusive devotion to the Rolando-Stilling method, and it is high time that its delusive teachings be corrected by the other special methods of research.

XVII.—Relation of cortex cerebri to adjacent parts.

The most important researches of Dr. von Monakow, those which are in all respects his own, and which, if confirmed, will add greatly to our comprehension of cerebral architecture and physiology, are those upon the relations between cortical areas and portions of the thalamus, the corpora geniculata, and the lobus opticus. A portion of his experiments have already appeared in print,[2] and two other contributions were made this year to the German and the Swiss Science Congresses respectively. He was led to undertake these researches partly by Munk's physiological experiments, and partly by the fact, noted several times by Gudden, that after removal of one hemisphere in the rabbit,

[1] "Contributions to Encephalic Anatomy," chapter i, appendix note 42.—*Journal of Nervous and Mental Disease*, April, 1880.

[2] Ueber einige durch Extirpation circumscriptar Hirnrindenregionen bedingte Entwickelungshemmungen des Kaninchengehirns.—*Arch. f. Psychiatrie*, Bd. xii, Heft 1.

Weitere Mittheilungen über durch Extirpation circumscriptar Hirnrindenregion bedingte Entwickelungshemmungen des Kaninchen.—*Idem*, Heft 3.

the thalamus of the same side was smaller. He also admits that Luys has for some time taught that definite regions of the cortex stood in relation to definite portions or nuclei of the thalamus, but this from pure theory.

After a few experiments on kittens, he was obliged, because of great mortality, to use rabbits, which he did with regret, because of their slight intelligence (compare Gudden and Ganser, whose rabbits seemed normal after removal of one hemisphere).

Expt. 1.—A portion of cortex and white substance of right hemisphere was removed from the parietal gyrus near the longitudinal fissure. This region M. considers to be just caudad of Ferrier's and Fürstner's area No. 6 (see fig. 1) ; about equivalent to Hitzig's No. 1 area in dogs and monkeys ; and also to Munk's centre for the leg. Caudad and laterad of extirpated region are Munk's region for the sensibility of the eye, and further his visual sphere. The extirpated zone is marked *a* in fig. 1.

Results : The nucleus externus of right thalamus is totally atrophied. Right corpus geniculatum laterale much atrophied, chiefly in its caudal portion. Right trapezium, pyramid, and lateral lemniscus a little smaller than their homologues. A part of the internal capsule in relation with the wound is atrophied. The lateral part of the crus cerebri is small, and the formatio reticularis reduced.

Expt. 2.—Removal of a portion of left occipital lobe (A. in fig. 1). Considers spot injured as equivalent to Ferrier's and Fürstner's centre No. 9, and to Munk's area A, the visual sphere of the dog.

Results : Slight atrophy of medullary substance near cicatrix, of caudal part of left internal capsule ; great atrophy of left corpus geniculatum laterale and of tractus opticus, of left tractus pedunclularis transversus, of the outer part of the nucleus externus of the thalamus. The left lobus opticus is slightly flattened ; the right optic nerve a little smaller than its fellow.

Conclusions: The atrophy extended from the visual sphere to the corpus geniculatum laterale and slightly to the rest of the optic apparatus ; it was in inverse degree to what follows enucleation of the eyeball. The corpus geniculatum laterale is, therefore, a centre for vision in

association with the cortical centre; the outer part of the nucleus externus which the author considers equivalent to the pulvinar,[1] is also a part of the optic apparatus.

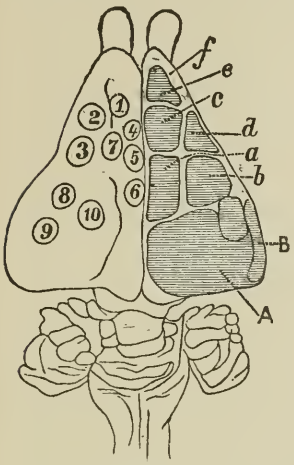


FIG. 1.[2]

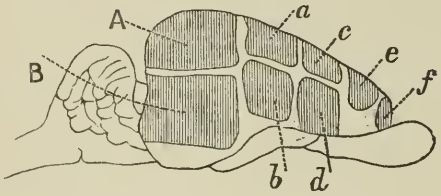


FIG. 2.[3]

The second article contains the following numerous experiments:

[1] Forel has shown that the lower mammals have no true pulvinar.

Monakow adds some remarks on the nomenclature of the nuclei of the thalamus, and follows Ganser's (Gehirn der Maulwurfs, *Morphol. Jahrbuch*, Bd. vii, p. 711) arrangement, into nucleus anterior (tuberculum anterius), nucleus internus, nucleus externus, and nucleus posterior.

[2] Explanation of cuts in the original articles.

Fig. 1.—Right hemisphere slightly modified from Monakow.

A. Zone of corp. gen. ext.

B. Zone of corp. gen. int.

a. Zone of optic thalamus.

b. Zone of stratum reticulare.

d. Zone d.

e and *f*. Zone of nucleus internus.

On the left hemisphere are placed the motor centres of Ferrier, as depicted in Fürstner's article, *Westphal's Archiv*, vol. vi, p. 725.

1. Raising of upper lip; rotation of head to right.
2. Drawing of mouth to right; masticatory movements on right; drawing of head to right.
3. The same.
4. Raising the right shoulder; extending the toes.
5. Retraction and adduction of the right paw; extension of toes.
6. Epileptic seizure.
7. Masticatory movements with the right upper lip and jaws; drawing of the head toward the left.
8. Shutting the eyes.
9. The same.
10. Indefinite.

Fig. 2.—Profile view of right hemisphere of figure 1.

Expt. 1.—Removal of zone *b*, fig. 1. Results : Atrophy of part of internal capsule (its third fifth about), extending from the wound centrally ; of nervous tissue laterad of the nucleus anterior of the thalamus (not atrophied). A slight atrophy of the corpus geniculatum laterale M. thinks is due to encroachment of lesion upon zone A. The lateral part of the crus cerebri is slightly reduced in size. Considers the part most atrophied in this experiment, the lateral adjunct to the nucleus anterius as the stratum reticulare (frontal part of *Gitterschicht*). Zone *b* is therefore the centre for the stratum reticulare.

Expt. 2.—Extirpation of zone B. This area occupies the greater part of the temporal lobe, and corresponds with Munk's auditory sphere B in dogs and monkeys. Results : Atrophy of connected fasciculus of corona radiata and internal capsule (caudo-ventral part), and of the corpus geniculatum mediale. There is also slight atrophy of the caudal part of the stratum reticulare (*Gitterschicht*). No changes could be detected in the acoustic nerve and its nucleus.

Conclusion : Zone B is the centre for the corpus geniculatum mediale. Query : Is the corp. gen. med. a primary centre for hearing as the corp. gen. lat. is for vision ?

Expt. 3.—Extirpation of extreme frontal end of hemisphere *f* and a part of *e* in fig. 1. Results : Atrophy of basal part of capsula interna, without and within the corpus striatum, and of a part of the nucleus internus. Corpus striatum preserved. Pyramidal tract partly atrophied.

Expt. 4.—Removal of zone *d*, including some of *b*. Results : Atrophy of corresponding part of internal capsule, and of caudal part of stratum reticulare.

Expt. 5.—Extirpation of area including *c*, *d*, *e*. These zones are frontad of *a* and *b*, and include nearly all the motor centres of Ferrier and Fürstner : its medial part corresponds to the paracentral lobule. Results : Atrophy of dependent fasciculi of internal capsule, without and within the corpus striatum (which is normal) ; atrophy of tuberculum anterius (nucleus anterius) to one half its normal size, an atrophy equally distributed in its two cell-groups. Thence the atrophy can be followed in two paths, separated by normal fibres coming from other parts of the brain : (*a*) The ventral atrophy involves the pyramidal tract (medial part of crus cerebri) ; the corresponding pyramid is al-

most totally atrophied, and the opposite half of the spinal cord contains the well-known crossed pyramidal atrophy. The corpus Luysii and the substantia nigra on the side of the injury are reduced in volume. (*b*) The dorsal atrophy expands into the area made up partly by the stratum reticulare, and by the laminæ medullares ext. The nucleus internus is slightly atrophied. The fasciculus Vicq D' Azyr is small, but not reduced in a degree corresponding with the atrophy of the nucleus anterius, Still another atrophy is produced by this operation, viz.: that of a longitudinal fasciculus in the white substance of the hemisphere, in its dorsal part, extending to the occipital lobe (fasciculus longitudinalis superior). Areas *c*, *e*, *f* constitute a pyramidal zone.

Monakow also extirpated five smaller areas in A, and separately the areas *c*, *d*, *e*. The results agreed with those obtained by experiments detailed above. Altogether more than fifty experiments were made.

Summary: If we associated the cortical zones with those central nuclei which were most atrophied by their extirpation, we have the following list:

Zone A, or visual sphere, is related to the corpus geniculatum laterale.

Zone *a* is related to the nucleus externus.

Zone *b* is related to the stratum reticulare.

Zone B is related to the corpus geniculatum mediale.

Zones *c*, *d*, *e* are related to the nucleus anterior and nucleus internus.

Zones *c*, *e*, *f* are related to the pyramidal tract.

It is observable that the nucleus posterior does not suffer in any of these experiments: very probably it is connected with strictly basal parts of the cortex.

Monakow believes, in consequence of these experiments, that each cortical area or zone is connected with more than one path or tract.

That the various nuclei of the thalamus as well as the corpora geniculata stand in definite relations to circumscribed cortical areas.

That the corpora geniculata medialis et lateralis are ana-

logues of the nuclei of the thalamus and should be considered as associated with them.

XVIII.—Connections of the cortical visual area with the optic apparatus.

Expt.[1] 1.—In a newly-born kitten removal of a large part of the parietal cortex and the subjacent white substance on one side. Autopsy in six months. Results: Sections frontad of wound show great atrophy of cortex of motor gyri and of the underlying white substance on the same side as the injury. Microscopic examination shows that the atrophy bears chiefly upon the third layer of cells in the cortex, that containing the larger ganglion cells (giant-cells of Betz); these are entirely absent. Section in the injured region; the corpus striatum is normal, but the fasciculi of the internal capsule which normally traverse it are absent,[2] except the ventral bundle derived from the lobus olfactorius. The optic nerve of the same side is smaller (its transverse diameter is less) than its fellow; this being due, in Monakow's opinion, to absence (atrophy) of the fasciculus lateralis, which has a connection with the cortical visual area (encroached upon by the wound). Further caudad the tractus opticus is smaller on the operated side; the tuberculum anterius (nucleus anterior) of the thalamus is wholly atrophied. The commissura anterior and the temporal lobe are normal. The nucleus externus thalami is almost wholly atrophied, while the nucleus internus is preserved. The part dorsad of the corpus geniculatum lat., which M. holds to be the equivalent of the human pulvinar, is fairly preserved. The corp. genic. lat. itself is somewhat reduced, but the mediale is normal. The lobus opticus on the injured side is smaller than its fellow, having suffered atrophy in its middle medullary layer. The medial part of the crus cerebri is much atrophied, and the lemniscus less developed on the injured side. The fasc. Vicq d'Azyr and medial ganglion of the corpus mammillare are partly atrophied. In the tegmentum there is absence of the pyramidal tract and diminution of the lemniscus. In the caudal part of the pons there is no pyramid on the side of injury, but the slight atrophy of the lemniscus gradually ceases.

[1] Experimentelle Untersuchungen über umschriebene Hirnrindenatrophien. Vortrag gehalten an der 56 Versammlung Deutscher Naturforscher und Aerzte. Freiburg, Sept., 1883.

[2] Von Gudden obtained a similar result in his experiment of removal of the motor gyri, *vide* p. [illegible]

EXPT.[1] 2.—In a newly-born rabbit, a simple oblique stabbing wound was made with a narrow knife in the temporal lobe, in a medio-ventrad direction. Autopsy in three and a half weeks. It was found that the caudal part of the internal capsule (Gratiolet's optic fasciculus), its connection with the corpus geniculatum mediale, and the tractus opticus, had been divided; the crus cerebri very slightly injured.

Results: Sections through the brain frontad of the injury showed the cortex normal, but its internal capsule less developed; caudad of the injury, in the occipital lobe there is marked atrophy of the cortex and white substance, due to section of the internal capsule. There is complete atrophy of the corpus geniculatum laterale (greater than can be accounted for by section of the tractus opticus). The lobus opticus on the same side as the injury is distinctly smaller. The corp. genic. mediale is completely atrophied from section of the fibres connecting it with the internal capsule. The various nuclei of the thalamus are normal. Microscopic examination of the atrophied occipital cortex showed that the atrophy affected mainly the third layer, or layer of large ganglion cells; they were entirely absent. The cells of the fifth layer were slightly reduced. In the small lobus opticus it is seen that the atrophy bears chiefly upon the superficial medullary layer, whose cells are fewer and smaller. After removal of the visual area alone (B in fig. 1), the atrophy of the lobus opticus is not of these cells, but is most marked in the middle medullary layer. In the above-detailed experiment there is also some atrophy of this layer, because a part of the optic fasciculus going to the cortex was injured. The atrophy of the superficial medullary layer is, however, much greater than after enucleation of one eyeball.

The results of these experiments, Monakow's first and second set of experiments upon the relations of the cortex and the thalamic nuclei (*including the corpora geniculata*).

What is more important, and what, if confirmed, will form an epoch in this department of experimental physiology, is the production of an ascending (centripetal) atrophy of the cortex by section of fasciculi of the internal

[1] Ueber die Ursprungscentren des Nervus Opticus, und deren Beziehungen zur Grosshirnrinde. Vortrag gehalten an der 66 Versammlung der Schweizerischen Naturforschenden Gesellschaft, Zürich, August, 1883.

capsule. It will be remembered that both Gudden and Monakow (see corpus restiforme) have shown that after section of the pyramidal tract low down (caudad) there was no ascending (centripetal) degeneration, or at most only in a very slight degree for a millimetre or two. But in both the last experiments section of the internal capsule (in expt. 1 its frontal division, in expt. 2 its occipital division) caused distinct atrophy of the associated cortical regions, in which mainly the third cell-layer (that of giant-cells) was atrophied.

The first experiment also corroborates Gudden's finding, that the corpus striatum has no corona radiata.

Another important result (of expt. 1) is the apparent demonstration that there is a degree of anatomical continuity between the cortical visual area and the optic *nerve* (its fasciculus lateralis). This is in opposition to von Gudden's results.

The general agreement between the results of physiologists (Munk, Hitzig, Ferrier, and others) and those of von Monakow is striking, and affords supplementary evidence of their approximate exactness.

Dr. von Monakow has recently made an autopsy of a human case [1] which strongly supports his and Munk's experiments on the visual cortical area.

There was in this case an old (probably five years old, judging by the imperfect history of the case) yellow patch (softening due to blockade of branches of the right posterior cerebral artery) in the right occipital lobe, more especially destroying the cuneus. Previous to the patient's reception in the asylum he had had "imperfect vision," which was explained by finding homonymous hemianopsia. In sections, one can trace, in the clearest manner, a band of degeneration from the patch in the occipital division of the internal capsule (Gratiolet's optic fasciculus) frontad and mediad to the corpus geniculatum laterale and pulvinar. The pulvinar is al-

[1] Unpublished.

most entirely atrophied, and the corp. genic. lat. largely so ; its folds are absent. The crus of the lobus opticus (brachium) is also in a state of secondary degeneration (granular cells, excessive staining by carmine). These changes border closely on the corp. genic. mediale which is normal, a fact which speaks positively against a primary disease here (besides the blood-vessels of this region were healthy). The lobi optici are equal and present no changes to the naked eye, but microscopic examination shows that in the right lobus the middle medullary layer (*mittleres Mark* of Ganser) contains fewer and smaller cross-cut bundles of nerve fibres. The atrophy is about the same as in Ganser's rat B (*vide* p. 142 of ARCHIVES for October). The lateral and medial parts of the lemniscus are smaller on the side of the lesion. It should be stated that further frontad the lateral part of the corp. genic. lat. is completely atrophied, while its medial part is preserved ; von Monakow is disposed to conclude that the former is connected with the cuneus, while the latter receives its innervation from the rest of the visual cortical area.

The tractus opticus on the side of the lesion is much reduced in size. Beyond the chiasm, the atrophy is traceable in both optic nerves ; the degenerated part standing out clearly marked by an excess of carmine. The right optic nerve exhibits a patch of degeneration in its lateral aspect (fasciculus lateralis ; the left nerve, in its medial aspect (fasciculus cruciatus).

XIX.—Connections of the optic nerve with the "primary optic centres." [1]

EXPT. 1.—In a newly-born rabbit, one eyeball was enucleated. Autopsy after one year. Results : Complete atrophy of injured optic nerve ; atrophy of tractus opticus on the opposite side of its fibres overlying the corp. geniculatum lat. Also atrophy of this nucleus, more especially in its lateral part. Microscopic examination shows that this atrophy affects the fundamental or intercellular substance, and that the peculiar globular cells are about as on the normal side, only very much closer together. The lobus opticus is somewhat smaller on the side opposite the injury, and microscopic examination shows that the atrophy involves both cells and fibres in the superficial medullary layer (*oberflächliches Mark* of Ganser). No change in the cortex cerebri. In considering this experiment it should be borne in mind that in the rabbit the optic nerves almost totally decussate.

[1] Unpublished.

Expt. 2.—In a newly-born kitten, one eyeball was enucleated. Autopsy in three months. Results : Complete atrophy of injured optic nerve ; both tractus optici are smaller than normal, the one opposite the lesion a little flatter than its fellow. [The optic decussation in cats is considered by M. to be nearly equal.] Both corpora genic. lat. are smaller, as are also the adjacent regions equivalent to the pulvinar. The streaks normally present in the corp. genic. lat. are absent, and the lateral aspects of the pulvinars exhibit an atrophic indentation. The lobi optici are about equally reduced in size, and microscopic examination shows the atrophy to bear chiefly upon the superficial medullary layer (Ganser's *oberflächliches Mark*), mostly in its fibres, but also somewhat in its ganglion cells.

I cannot close this review without expressing my appreciation of the courtesy with which Doctor von Monakow received me at St. Pirminsberg, and the pains he took to demonstrate all his preparations. He, as well as Professor von Gudden, have allowed me to make use of unpublished material, and its appearance in the Archives of Medicine is to be considered as preliminary original communications from these gentlemen.

UNIVERSITY OF CALIFORNIA LIBRARY
Los Angeles
This book is DUE on the last date stamped below.

Form L9–52*m*-7,'61(O1437s4)444